CHAPTER 4: RETENTION BASINS

The terms **detention** and **retention** many times are considered to have the same meaning. However, in this guidebook, a **retention** basin will be defined as a stormwater management practice that captures stormwater runoff, and does not directly discharge to a surface water body. Water that is "retained" is "discharged" from the basin either by infiltration or evaporation. Retention basins will typically have minimal impact on 100-year flood peaks, since they are usually not designed to retain the 100-year runoff.

The two driving forces in the design of a retention (infiltration) basin is the amount of runoff that will be retained, and the infiltration capacity of the soil. Since infiltration capacity is critical, soils that contain a high percentage of silt of clay cannot be used for infiltration basins.

The use of retention (infiltration) basins can result in a high percentage of pollutant removal. Table 4.1 indicates estimated removal rates for a retention (infiltration) basin for two types of sizing requirements.

Table 4.1 - Estimated Long-Term Pollutant Removal Rates (%) For Infiltration Basins

POLLUTANT	SIZING RULE 0.5 in/imper acre	SIZING RULE 2-yr runoff volume
SEDIMENT	75%	99%
TOTAL PHOSPHOR	50-55%	65-75%
TOTAL NITROGEN	45-55%	60-70%
TRACE METALS	75-80%	95-99%
BOD	70%	90%
BACTERIA	75%	98%

(Source: Schueler 1987, reference 38)

The larger the basin, the more efficient the basin will be at removing pollutants. However, since larger basins cost more, there will be a point at which the additional cost of a larger basin will not translate into a significant increase in the efficiency of the basin.

Following is a list of guidelines for the design of a retention (infiltration) basin:

1. **Volume Requirements** - for water quality purposes.

   The most widely applied runoff methods include:

   a) Storage of 0.5 inches of runoff per impervious acre.
   b) Storage of 0.5 inches of runoff from the entire drainage basin.
   c) Storage of the volume of runoff from a 2 -year storm.

If the basin is to provide water- **quantity** benefits, the retention volume has to be significantly higher, which may not be feasible. It would be more appropriate to use a retention basin to capture the "first flush" and use a detention basin for water quantity control.

2. **Infiltration Capacity**

The other design consideration for a retention basin is the infiltration capacity of the soil. For a site to be considered feasible to use a retention basin design, the infiltration capacity of the soil should be greater than 0.52 inches per hour (reference 38).

To insure that an accurate evaluation of the soil type is made at the basin, soil borings are needed at least 5 feet below the bottom of the proposed basin. Adequate soil information is essential to have before the basin is designed. Without such information, there is a high probability that the basin will fail.

Table 4.2 - Infiltration Rates for Soil Groups

Soil Class	Infiltration Rate (inches/hour)	National Resource Conservation Service Hydrologic Soil Group
Sand	8.0	A
Loamy Sand	2.0	A
Sandy Loam	1.0	B
Loam	0.5	B
Silt Loam	0.3	C
Sandy Clay Loam	0.2	C

From table 4.2, only soil groups A & B would be feasible for the use of an infiltration retention basin. If the soils are C or D, the basin would likely remain wet and eventually lose its capacity of retaining stormwater runoff. In addition, if the basin remains wet, the basin may be considered an eye sore, and adjacent property owners will likely want the basin filled in.

A 1987 survey in Maryland by Pensyl and Clement (reference 32) found about one -third of the infiltration basins contained standing water. The reasons given for the standing water include, low infiltration rates due to compaction during construction, sedimentation, and poor preliminary soil investigation.

Ferguson (reference 14) offered additional views, in which he indicated that the design of retention basins is typically based only on a design runoff; the everyday rainfall and runoff events are not considered. Ferguson also concluded that "a basin sized only for a 0.5 inch first flush is not likely to be capable of capturing the first flush; a basin sized only for a design storm is not likely to be capable of capturing the design storm..." This conclusion is a result of basin designs that ignore the "everyday" flows, which can accumulate in the basin and reduce the capacity of the basin.

The "everyday" flows accumulate in a retention basin when the "flow" into the basin exceeds the infiltration capacity of the basin. As a factor of safety, it is suggested that the infiltration capacity of the basin floor be multiplied by at least 0.5 when designing the basin. The factor of safety is to try to account for the compaction of the basin floor and the accumulation of sediments on the basin floor. If the retention basin happens to be an area that will be used as a recreation area, such as a playground, it would be advisable to apply an additional factor of safety. Heavy foot traffic will tend to compact the basin floor, and reduce the infiltration capacity.

The factor of safety in combination with a minimum infiltration rate of 0.5 inches/hour should minimize the potential for standing water occurring in the retention basin.

3. **Basin-bottom elevation**

To ensure that the basin will be able to function properly, the basin bottom should be at least 4 feet above the seasonal high-water table and/or bedrock.

4. **Maximum ponding time of 72 hours**

If the ponding time exceeds 72 hours, it is possible that the basin will be continually wet. An infiltration basin that is continually wet cannot be maintained properly, and may turn into an eye sore.

5. **10 feet from the nearest basement wall**

The retention basin should be placed at least 10 feet from the nearest basement wall.

6. **100 feet from nearest well**

To limit the possibility of contamination, the basin should be located at least 100 feet from the nearest water supply well.

7. **Not placed in filled areas**

The basin should <u>not</u> be constructed in "filled" areas.

8. **Use water-resistant grasses**

The side slopes and bottom should be vegetated using grasses that can withstand being covered by water for up to 72 hours.

9. **Avoid compaction of basin bottom.**

In many instances, the retention basin is only a portion of a large project. The basin area should be staked out and avoided by heavy equipment during construction to prevent compaction of the soil. Care must also be taken during the actual construction of the retention basin to prevent compaction of the bottom of the basin by construction equipment. To prevent compaction, it may be necessary to excavate from the sides of the basins, rather than placing the equipment on the basin bottom.

10. **Provide overflow area**

Provide an area which may overflow should the design criteria be exceeded. The area should be stabilized to prevent erosion. When overflow occurs, a drainageway must be available to carry the water.

11. **Reduce amount of sedimentation that gets into the basin**

It is essential to remove as much sedimentation as possible before the flow gets to the basin. The use of erosion-control measures, sedimentation basins, and grass filter strips before and during basin construction is very effective. The retention basin should **not** be used as a sedimentation basin during the construction phase. The sediment will tend to seal the basin bottom, which will significantly reduce the infiltration capacity of the basin. If there are no other alternatives, **all** the sediment that has accumulated during construction should be removed down to "natural" soil.

12. **Removal of sediment**

Even with erosion control measures in place, sedimentation may accumulate in the basin. If the sedimentation is not removed, the basin floor will "seal" and the basin will turn into a "mud hole". The sedimentation should be allowed to dry before **light** equipment is used to remove the sedimentation. Once the sedimentation is removed down to the basin floor, the floor should be tilled and revegetated to restore infiltration rates.

EXAMPLE 4.1: Retention Basin Design

The runoff from a 10-acre site is to be retained. Estimate the basin size given the following criteria:

a) The basin is commercially developed (85% impervious)
b) Retain 0.5 inches of runoff/impervious acre
c) Drain pond in at least 48 hours
d) Infiltration capacity of the soil is 1.0 inch/hour
e) Multiply the infiltration capacity of the basin floor by 0.5 as a factor of safety.

I) **Compute runoff volume**:
(Total Area) x (% impervious) x retention requirement
10 acres x 0.85 x 0.5 in/acre = 4.25 acre -in (0.35 acre-ft)

II) **Compute the basin depth needed**:
(infiltr. time) x (infiltr. capacity) x factor of safety
48 hrs. x 1.0 in./hr x 0.5 = 24 in.; or 2 feet in 48 hours

III) **Compute the surface area of the basin**:
volume of runoff / infiltration available
0.35 acre-feet / 2 feet = 0.175 acres = 7623 square ft

suggest **8000 square feet**

It should be noted that this sizing estimate has excluded the infiltration that may be occurring through the sides of the retention basin. For shallow retention basins such as this one, the infiltration through the sides will be much less than will be occurring through the basin floor.

PROBLEMS AND CONCERNS WITH RETENTION BASINS

Potential Groundwater Contamination

Under current State of Michigan regulations, a ground-water discharge permit is not required for the discharge of stormwater via an infiltration basin.

Studies done on infiltration basins in Long Island, New York and Fresno, California (reference 51) indicated metals and other pollutants accumulated in the upper few inches of the soil in the basin and did not reach the groundwater. Pitt (reference 33) noted that these studies did not thoroughly investigate the impact of soluble organics on the groundwater.

If soluble organics are present and may be picked up by stormwater runoff, from areas such as industrial facilities, it is best to identify the source of the pollutants and eliminate the source.

If source elimination is not possible, the distance between the basin bottom and the seasonal high ground-water table should be kep t as large as possible. The four-foot distance, mentioned above is a minimum for all retention basins, if organics are present the distance should be greater. At this time there is no "rule of thumb". The State of Wisconsin considers sites that have a 20-foot depth to ground water as being minimally susceptible to ground water contamination.

Additional study is needed into the potential groundwater problems from soluble organics that may result from infiltration of stormwater runoff.

Sedimentation

If sedimentation is a problem in the drainage basin, it is essential to provide some method of capturing or reducing the sedimentation before it reaches the retention basin. Excessive sedimentation will "seal" the bottom of the basin, which will result in a continually wet basin. Maintenance may be necessary to remove the excess sedimentation that may accumulate in the bottom of the basin, loosen the bottom soil, and revegetate.

Property Owners

If on-site retention basins are used, the property owner ma y view it as a drainage problem, especially if the infiltration capacity has been reduced. Since the basin is on site, there may be problems keeping the basin maintained. In addition, it is possible that the property owner will become upset with having the water accumulating on the property and may try to fill in or regrade the basin. To minimize problems from property owners, it would be advisable to place the basins in "common" areas where they can be maintained.

Oil and Grease

If the runoff from the drainage basin will contain oil or grease, it will be necessary to use an oil/grit separator to remove these pollutants before they reach the retention basin (see figure 4.1). The oil and grease will tend to seal the basin bottom, which will result in standing water. A typical oil/grit separator consists of three chambers, and provides 400 cubic feet of wet storage per acre of contributing drainage area. The first chamber captures sediment, while the second chamber captures the oil and gas films which are eventually absorbed by particles and settle. The pool of water in the first two chambers should be at least four feet deep and is controlled by an inverted elbow. Between the first two chambers are two six-inch orifices protected from clogging by a trash rack. The separator will have to be cleaned out regularly for it to remain functional.

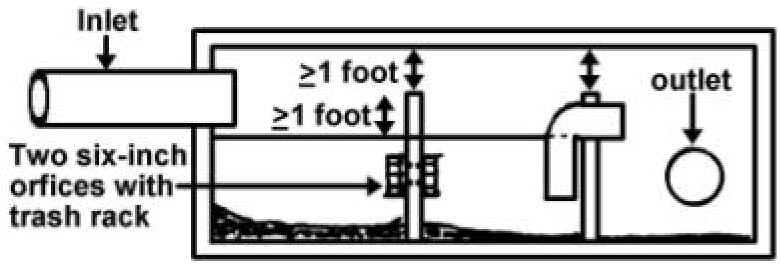

Figure 4.1 Schematic of Oil/Grit Separator (Reference 38)

Winter Freeze-up

When the ground is frozen there will be very little infiltration capacity available to the basin. As a result, winter and early spring runoff may not infiltrate immediately, but will pond in the basin. It is very likely that the capacity of the basin will be exceeded during early spring. If extra storage capacity is not provided for in the pond, a stabilized overflow area should be provided.

Slope Stability

Whenever water is introduced into the ground, there is a potential that the stability of the soil will be impacted as a result of the infiltration. It is suggested that a geotechnical engineer be consulted to determine if water from the infiltration basin will result in stability problems in the vicinity of the basin.